IMAGE PROCESSING USING OPTICALLY TRANSFORMED LIGHT

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to the field of electro-optical systems and more specifically to image processing using optically transformed light.

BACKGROUND OF THE INVENTION

Electro-optical systems may generate an image by processing image information. Known electro-optical systems, however, typically cannot efficiently and effectively process image information from multiple sensors. Consequently, known electro-optical systems for generating an image may be unsatisfactory in certain situations.

SUMMARY OF THE INVENTION

In accordance with the present invention, disadvantages and problems associated with previous techniques for generating an image may be reduced or eliminated.

According to one embodiment of the present invention, processing image information includes receiving light having image information. A first optical transform is performed on the light to yield a first optically transformed light, and a second optical transform is performed on the light to yield a second optically transformed light. A first metric is generated in accordance with the first optically transformed light, and a second metric is generated in accordance with the second optically transformed light. The first metric and the second metric are processed to yield a processed metric. An inverse optical transform is performed on the processed metric to process the image information of the light.

Certain embodiments of the invention may provide one or more technical advantages. A technical advantage of one embodiment may be that light is optically transformed to generate metrics that are processed. The processed metrics are inversely optically transformed to generate an image. By optically transforming light, image information may be efficiently processed.

Certain embodiments of the invention may include none, some, or all of the above technical advantages. One or more other technical advantages may be readily apparent to one skilled in the art from the figures, descriptions, and claims included herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and its features and advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a block diagram illustrating one embodiment of a system for processing image information; and

FIGURE 2 is a flowchart illustrating one embodiment of a method for processing image information.

DETAILED DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention and its advantages are best understood by referring to FIGURES 1 and 2 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

FIGURE 1 is a block diagram illustrating one embodiment of a system 10 for processing image information. System 10 receives light that includes image information. The light is optically transformed and received by a plurality of sensors. Metrics describing the optically transformed light are processed in order to generate an image from the image information.

According to the illustrated embodiment, system 10 includes sensor paths 20a-b, an image processor 22, an inverse optical transformer 24, and a display 26 coupled as illustrated in FIGURE 1. System 10 receives light reflected from an object. The light carries image information that may be used to generate an image of the object. Sensor paths 20a-c optically transform the received light and generate metrics that describe the optically transformed light. Image processor 22 processes the metrics in order to yield a processed metric. Inverse optical transformer 24 performs an inverse optical transform on the processed metric in order to generate an image that may be displayed at display 26.

According to one embodiment, sensor path 20a-b includes an optical transformer 30a-b, a sensor 32a-b, and a processor 32a-b coupled as illustrated in FIGURE 1. Optical transformer 30a-b may comprise any device operable to perform an optical transform on light, for example, a lens, a filter, or an electro-optical element.

The optical transform may comprise a Fourier or Fourier-based transform, a geometrical transform, or any other suitable transform.

Optical transforms may be used to identify and represent features of an image. For example, a Fourier transform comprises a series expansion of an image function in terms of cosine image basis functions that expresses an image as a summation of cosine-like images. A geometrical transform represents geometric features of an image as different geometric features. According to one embodiment, optical transforms may be used to express the length and width of a shape in an image as a ratio. According to another embodiment, optical transforms may be used to express the eccentricity of a shape in an image as a numerical value. According to yet another embodiment, optical transforms may be used to represent a predetermined shape of an image such as the shape of a missile as a circle. Optical transforms may be formulated such that the transformed image may be more easily identified.

The optical transforms performed by optical transformers 30a-b may be substantially similar or may be compatibly different. Compatibly different optical transforms may comprise different optical transforms that do not cancel each other out. For example, an optical transform performed by optical transformer 30a may target a specific shape, while an optical transform performed by optical transformer 30b may target heat.

Sensor 32a-b senses the optically transformed light to generate a signal such as a digital or analog signal that describes the image information of the light. Sensor 32a-b may detect certain types of energy of the

light, for example, infrared energy. Sensor 32a-b may comprise, for example, a charge-coupled device (CCD), a lead salt sensor, or other suitable sensing device embodied in any suitable manner such as in a pixel or in a pixel array.

Processor 34a-b receives a signal from sensor 32a-b and generates a metric in response to the signal. As used in this document, the term "processor" refers to any suitable device operable to accept input, process the input according to predefined rules, and produce output. A metric may comprise, for example, a matrix that describes particular features of an image. The particular features may include, for example, the average spatial frequency of an area, the longest edge of an image, or the circles of an image. Optically transforming a light may yield metrics that are more easily analyzed. Typically, optically transforming the light may correlate image information for more efficient analysis.

Image processor 22 processes the metrics received from sensor path 20a-b to generate a processed metric. Image processor 24 may perform any suitable type of image processing. For example, image processor may fuse the metrics to form a fused image. The metrics may be fused by selecting data from each metric, and then forming a processed metric from the selected data. The data may be selected based upon which metric includes the most image content. "Each" as used in this document refers to each member of a set or each member of a subset of a set.

Metrics m_1 and m_2 may be fused according to a function $f(m_1,m_2)$ of metrics m_1 and m_2. For example, the metrics m_1 and m_2 may be fused according to the function $f(m_1,m_2) = m_1+m_2$ or other suitable function. The function

$f(m_1,m_2)$ may combine the metrics according to weights assigned to the metrics. For example, the metrics may be combined according to the function $f(m_1,m_2) = w_1m_1/w_2m_2$ or the function $f(m_1,m_2) = w_1m_1+w_2m_2$, where w_1 represents a weight assigned to metric m_1, and w_2 represents a weight assigned to metric m_2. Any other function or procedure for combining the metrics, however, may be used.

As another example, image processor 22 may locate a target using the metrics received from sensor paths 20a-b. The metrics may be designed to identify certain shapes such as circles or edges of an image, and image processor 22 may locate targets that include the identified shapes. Image processor 22, however, may perform any other suitable processing such as industrial sorting.

Image processor 22 may make compatible different types of data received from sensor paths 20a-b. For example, image processor 22 may be used to make compatible different resolutions of sensors 32a-b. As an example, sensor 32a may have an image area that has 60,000 pixels, while sensor 32b may have an image area that has 1 million pixels. Image processor 22 may be used to efficiently normalize the different resolutions.

Inverse optical transformer 24 performs the inverse of the optical transforms performed by sensor paths 20a-b. If different optical transforms are performed by different sensor paths 20a-b, different inverse optical transforms may be performed on the processed metric in order to invert the data. The inverse optical transform may be performed in parallel, and may be performed in a relatively predictable amount of time.

Display 26 displays an image generated from an inverted metric received from image processor 24. Display 26 may include any device or combination of devices suitable for displaying an image. For example, display 26 may include a television monitor, a video enabled eyepiece, or a handheld display.

Modifications, additions, or omissions may be made to system 10 without departing from the scope of the invention. For example, system 10 may include any suitable number of sensor paths 20a-b, and may include more or fewer than two sensor paths 20a-b. Moreover, the operation of the system may be performed by more or fewer modules. For example, the operation of image processor 22 and inverse optical transformer 24 may be performed by one module, or the operation of image processor 22 may be performed by more than one module. Additionally, functions may be performed using any suitable logic comprising software, hardware, other logic, or any suitable combination of the preceding.

FIGURE 2 is a flowchart illustrating one embodiment of a method for processing image information. According to the embodiment, light carrying image information is received. The received light is optically transformed to generate metrics that are processed in order to yield a processed metric. An inverse optical transform is performed on the processed metric in order to generate an image that may be displayed.

The method begins at step 100, where system 10 receives light carrying image information that may be used to generate an image of an object. Steps 102 through 114 may be performed for each sensor path 20a-b of system 10, and the sequences of steps 102 through 114 for the

sensor paths 20a-b may be performed concurrently. A sensor path 20a is selected at step 102. Optical transformer 30a optically transforms the received light at step 110. Optically transforming a light may yield metrics that may be more efficiently processed. Typically, optically transforming the light correlates the data for more efficient analysis.

Sensor 32a senses the optically transformed light at step 112, and generates a signal in response to sensing the light. Processor 34a generates a metric for the light at step 114 in response to the signal received from sensor 32a. A metric may comprise, for example, a matrix that describes particular features of the image such as the average spatial frequency of an area, the longest edge of an image, or the circles of an image.

If there is a next sensor path 20b at step 116, the method returns to step 102 to select the next sensor path 20b. If there is no next sensor path at step 116, the method proceeds to step 118. Image processor 22 processes the metrics received from processors 32a-b to generate a processed metric. Image processor 22 may, for example, fuse the metrics or may use the metrics to locate a target. Inverse optical transformer 24 inversely optically transforms the processed metric at step 120 in order to invert the data. Display 26 reports the results at step 122. After reporting the results, the method terminates.

Modifications, additions, or omissions may be made to the method without departing from the scope of the invention. For example, additional or other suitable filtering or processing may be performed at any step of the method. Additionally, steps may be performed in any

suitable order without departing from the scope of the invention.

Certain embodiments of the invention may provide one or more technical advantages. A technical advantage of one embodiment may be that light is optically transformed to generate metrics that are processed. The processed metrics are inversely optically transformed to generate an image. By optically transforming light, image information may be efficiently processed.

Although an embodiment of the invention and its advantages are described in detail, a person skilled in the art could make various alterations, additions, and omissions without departing from the spirit and scope of the present invention as defined by the appended claims.